However, the insulator 140 surrounding the central conductor 130 is replaced by an insulating coating 140, while the shield 15 is replaced by a conductor coating 150 and the insulator 16 by an insulator coating 160. As for the embodiment of FIG. 3, the conductor coating 150 and insulator coating 160 have been removed from a portion of the distal end of tip 170. Also, the proximal end (not shown) of this coaxial cable is adapted to connection to the standard antenna input of control station 12 (FIG. 1).

Variants may be envisaged.

For instance, the outer conductor and insulator, 15–16 resp. 150–160, need not be removed from a portion of the distal end 17 resp. 170. Similarly, the outer conductor and insulator may be removed a far greater length from the distal end 17 resp. 170, and it is also possible to have them removed to the proximal end of the guidewire, outside of the patient.

Subject to the precautions or requirements inherent to patient protection, it would be also possible to have the guidewire comprised of a naked conductor 13 or 130, while the insulator 14 or 140 and outer conductor 15, 150 and insulator 16, 160 would be installed towards the proximal end of the guidewire, outside of the patient.

Similarly, the coaxial configuration shown is not compulsory, being possible to have the open wire length antenna as a naked or insulated wire with appropriate polarities arranged for connection thereof to the antenna input of the control station.

FIG. 4 shows one such possibility, in which the open wire length antenna is made of two twisted conducting strands 18 and 19 insulated from one another by appropriate coatings 20 and 21.

FIG. 5 also shows one such possibility, in which the open wire length antenna is made of two conducting strands 22 and 23 parallel to one another and separated by insulator coatings 24 and 25.

As for the previous embodiments, the strands 18 and 19, respectively 22 and 23, may have the same length or unlike lengths.

In both the embodiments of FIG. 4 and FIG. 5, the channels 30 which are left open along the insulated strands may be used for further investigation purposes when the open wire length antenna is placed in the lumen of a catheter, for example for pressure readings.

I claim:

1. A medical appliance comprising an elongated signal-receiving antenna for detecting and providing magnetic resonance response signals, the antenna adapted to be inserted into the body during magnetic resonance imaging procedures and for providing the response signals used for calculating a position of the medical appliance in the body, wherein the antenna comprises an open wire length including first and second conductor means having proximal ends adapted and arranged for interconnection to a receiver to couple the detected resonance response signals to the receiver, spaced-apart distal ends, and at least a first insulator means for physically separating and electrically insulating adjacent portions of the first and second conductor means, the distal ends of the first and second conductor means and the at least first insulator means adapted and arranged for exposure to a field of electromagnetic energy during a magnetic resonance procedure to couple electromagnetic energy from the field into the antenna and detect and provide the magnetic resonance response signals to the proximal ends of the conductor means.

2. A medical appliance according to claim 1, wherein the open wire length antenna is formed of a coaxial cable including the first and second conductors in a coaxial arrangement.

3. A medical appliance according to claim 1. wherein the open wire length antenna is formed of a cable having the first conductor enclosed in the first insulator. the first insulator surrounded by the second conductor and the second conductor encased in a second insulator. and wherein said first conductor and second conductor have the same length.

4. A medical appliance according to claim 1. wherein the open wire length antenna is formed of a cable having the first conductor enclosed in the first insulator. the first insulator surrounded by the second conductor. and the second conductor encased in a second insulator. and wherein said first conductor and second conductor have unlike lengths.

5. A medical appliance according to claim 1. wherein the open wire length antenna is made of the first conductor. the first insulator includes a first insulating coating applied on said first conductor. the second conductor includes a conducting coating surrounding said first insulating coating. and the antenna further includes a second insulating coating applied on said conducting coating. and wherein said first conductor and conducting coating have the same length.

6. A medical appliance according to claim 1. wherein the open wire length antenna is made of the first conductor. the first insulator includes a first insulating coating applied on said first conductor. the second conductor includes a conducting coating surrounding said first insulating coating. and the antenna further includes a second insulating coating applied on said conducting coating. and wherein said first conductor and conducting coating have unlike lengths.

7. A medical appliance according to claim 1. wherein the first and second conductors of the open wire length antenna include conducting strands insulated from one another.

8. A medical appliance according to claim 7. wherein the first and second conductor means are parallel to one another.

9. A medical appliance according to claim 7. wherein the first and second conductor means are twisted.

10. A medical appliance according to claim 7. wherein the first and second conductor means have the same length.

11. A medical appliance according to claim 7. wherein the first and second conductor means have unlike lengths.

12. A medical appliance according to claim 1. wherein the open wire length antenna forms at least a part of a guidewire for vascular procedures.

13. A medical appliance antenna system for use in connection with magnetic resonance imaging procedures. including:

a medical appliance comprising an elongated signal-receiving antenna for detecting and providing magnetic resonance response signals. the antenna adapted to be inserted into the body during magnetic resonance imaging procedures and for providing the response signals used for calculating a position of the medical appliance in the body. wherein the antenna includes an open wire length including first and second conductors having proximal ends adapted and arranged for interconnection to a receiver to couple the detected response signals to the receiver. spaced-apart distal ends. and at least a first insulator for physically separating and electrically insulating adjacent portions of the first and second conductors. the distal ends of the first and second conductors and the at least first insulator adapted and arranged for exposure to a field of electromagnetic energy during a magnetic resonance procedure to couple the electromagnetic energy from the field to the antenna and detect and provide the magnetic resonance response signals to the proximal ends of the conductors; and

a receiver electrically connected to the antenna for receiving the magnetic resonance response signals and pro-

viding information representative of the position of the medical appliance.

14. A medical appliance according to claim 13, wherein the open wire length antenna is formed of a coaxial cable including the first and second conductors in a coaxial arrangement.

15. A medical appliance according to claim 13, wherein the open wire length antenna is formed of a cable having the first conductor enclosed in the first insulator, the first insulator surrounded by the second conductor and the second conductor encased in a second insulator, and wherein said first conductor and second conductor have the same length.

16. A medical appliance according to claim 13, wherein the open wire length antenna is formed of a cable having the first conductor enclosed in the first insulator, the first insulator surrounded by the second conductor, and the second conductor encased in a second insulator, and wherein said first conductor and second conductor have unlike lengths.

17. A medical appliance according to claim 13, wherein the open wire length antenna is made of the first conductor, the first insulator includes a first insulating coating applied on said first conductor, the second conductor includes a conducting coating surrounding said first insulating coating, and the antenna further includes a second insulating coating applied on said conducting coating, and wherein said first conductor and conducting coating have the same length.

18. A medical appliance according to claim 13, wherein the open wire length antenna is made of the first conductor, the first insulator includes a first insulating coating applied on said first conductor, the second conductor includes a conducting coating surrounding said first insulating coating, and the antenna further includes a second insulating coating applied on said conducting coating, and wherein said first conductor and conducting coating have unlike lengths.

19. A medical appliance according to claim 13, wherein the first and second conductors of the open wire length antenna include conducting strands insulated from one another.

20. A medical appliance comprising an elongated and signal-receiving antenna for detecting and providing magnetic resonance response signals, the antenna adapted to be inserted into the body during magnetic resonance imaging procedures and for providing the response signals used for calculating a position of the medical appliance in the body, wherein the antenna comprises an open wire length including first and second conductors having proximal ends adapted and arranged for interconnection to a receiver to couple the detected resonance response signals to the receiver, spaced-apart distal ends, and at least a first insulator for physically separating and electrically insulating

adjacent portions of the first and second conductors, the distal ends of the first and second conductors and the at least first insulator adapted and arranged for exposure to a field of electromagnetic energy during a magnetic resonance procedure to couple electromagnetic energy from the field into the antenna and detect and provide the magnetic resonance response signals to the distal ends of the conductors.

21. A medical appliance according to claim 20, wherein the open wire length antenna is formed of a coaxial cable including the first and second conductors in a coaxial arrangement.

22. A medical appliance according to claim 20, wherein the open wire length antenna is formed of a cable having the first conductor enclosed in the first insulator, the first insulator surrounded by the second conductor and the second conductor encased in a second insulator, and wherein said first conductor and second conductor have the same length.

23. A medical appliance according to claim 20, wherein the open wire length antenna is formed of a cable having the first conductor enclosed in the first insulator, the first insulator surrounded by the second conductor, and the second conductor encased in a second insulator, and wherein said first conductor and second conductor have unlike lengths.

24. A medical appliance according to claim 20, wherein the open wire length antenna is made of the first conductor, the first insulator includes a first insulating coating applied on said first conductor, the second conductor includes a conducting coating surrounding said first insulating coating, and the antenna further includes a second insulating coating applied on said conducting coating, and wherein said first conductor and conducting coating have the same length.

25. A medical appliance according to claim 20, wherein the open wire length antenna is made of the first conductor, the first insulator includes a first insulating coating applied on said first conductor, the second conductor includes a conducting coating surrounding said first insulating coating, and the antenna further includes a second insulating coating applied on said conducting coating, and wherein said first conductor and conducting coating have unlike lengths.

26. A medical appliance according to claim 20, wherein the first and second conductors of the open wire length antenna include conducting strands insulated from one another.

27. A medical appliance according to claim 20 and further including a receiver electrically connected to the antenna for receiving the magnetic resonance response signals and providing information representative of the position and orientation of the medical appliance.

* * * * *

28. A medical apparatus for imaging a wall of a body cavity in a patient by interacting with a magnetic resonance imaging (MRI) system which generates a magnetic field gradient and electromagnetic (EM) radiation and transmits the gradient and EM radiation into the patient and receives a response signal indicative of a resonant response from the patient, the apparatus comprising:

an antenna including an open conductor length configured to be inserted into the cavity and provide the response signal, based on the resonant response from a region of the patient closely proximate the antenna, to the MRI system; and

a controller coupled to the antenna and configured to receive the response signal to obtain an image of the cavity wall proximate the antenna.

29. The medical apparatus of claim 28 wherein the controller is configured to calculate antenna location by calculating an image of the antenna, antenna position, and antenna orientation.

30. The medical apparatus of claim 28 wherein the controller is configured to repeatedly measure, reconstruct and store the image to obtain an increased resolution image of the cavity wall.

31. The medical apparatus of claim 28 wherein the antenna is configured to be capacitively coupled to an EM field generated by the EM radiation.

32. The medical apparatus of claim 28 wherein the cavity is defined by vasculature in the patient and wherein the antenna is configured for insertion into and passage through the vasculature.

33. The medical apparatus of claim 32 wherein the antenna forms at least a portion of a guidewire configured for insertion into the vasculature for use in positioning of a catheter.

34. The medical apparatus of claim 28 wherein the MRI system includes a response signal receiver and processor and a control station, and wherein the controller is implemented as a part of the control station or processor.

35. The medical apparatus of claim 28 wherein the antenna includes a first elongate conductor having a portion thereof forming the open conductor length, and a second elongate conductor, the first and second elongate conductors extending to a proximal end of the antenna.

36. The medical apparatus of claim 35 wherein the first and second elongate conductors are coaxially arranged along at least a portion of a length thereof.

37. The medical apparatus of claim 35 wherein the first and second elongate conductors are separated by an insulative layer.

38. The medical apparatus of claim 35 wherein the first and second elongate conductors are formed as a twisted pair.

39. The medical apparatus of claim 35 wherein the first and second elongate conductors are generally linear and generally parallel to one another.

40. A method of generating an image of a wall of a body cavity in a patient, the method comprising:

inserting an antenna including an open conductor length into the cavity;

generating a magnetic field gradient and electromagnetic (EM) radiation and transmitting the gradient and EM radiation into the patient;

transmitting a response signal, based on a detected resonant response from a region of the patient closely proximate the antenna, to a magnetic resonance imaging (MRI) processor;

receiving the response signal at the MRI processor; and

obtaining an image of the cavity wall proximate the antenna based on the response signal.

41. The method of claim 40 wherein obtaining an image comprises:

repeatedly calculating antenna location.

42. The method of claim 41 wherein calculating antenna location comprises:

calculating an image of the antenna.

43. The method of claim 41 wherein calculating antenna location comprises:

calculating antenna position.

44. The method of claim 41 wherein calculating antenna location comprises:

calculating antenna orientation.

45. The method of claim 40 wherein obtaining an image comprises:

repeatedly measuring, reconstructing and storing the image to obtain an increased resolution image of the cavity wall.

46. The method of claim 40 wherein transmitting a response signal comprises:

capacitively coupling the antenna to an EM field generated by the EM radiation to detect the resonant response.

47. The methos of claim 40 wherein the cavity is defined by vasculature in the patient and wherein inserting an antenna into the cavity comprises:

inserting the antenna into the vasculature; and

passing the antenna through the vasculature to a site to be imaged.

48. The method of claim 47 wherein the antenna is configured as a guidewire and further comprising:

positioning a catheter in the vasculature through use of the guidewire.

49. A method of generating an image of a blood vessel wall of a blood vessel in a patient, the method comprising:

inserting an antenna into the blood vessel;

passing the antenna through the blood vessel to a site to be imaged;

generating a magnetic field gradient and electromagnetic (EM) radiation and transmitting the gradient and EM radiation into the patient;

transmitting a response signal, based on a detected resonant response from a region of the patient closely proximate the antenna, to a magnetic resonance imaging (MRI) processor;

receiving the response signal at the MRI processor; and

obtaining an image of the blood vessel wall proximate the antenna based on the response signal.

50. A medical apparatus for imaging a blood vessel wall of a blood vessel in a patient by interacting with a magnetic resonance imaging (MRI) system which generates a magnetic field gradient and electromagnetic (EM) radiation and transmits the gradient and EM radiation into the patient and receives a response signal indicative of a resonant response from the patient, the apparatus comprising:

an antenna configured to be inserted into the blood vessel and passed along the blood vessel to a site to be imaged and to provide the response signal, based on the resonant response from a region of the patient closely proximate the antenna, to the MRI system; and

a controller coupled to the antenna and configured to receive the response signal and repeatedly calculate antenna location to obtain an image of the blood vessel wall proximate the antenna.

51. The medical apparatus of claim 50 wherein the antenna comprises an open conductor length.

52. The medical apparatus of claim 51 wherein the antenna includes a first elongate conductor having a portion thereof forming the open conductor length, and a second elongate conductor, the first and second elongate conductors extending to a proximal end of the antenna.

53. The medical apparatus of claim 50 wherein the antenna is configured to be capacitively coupled to an EM field generated by the EM radiation.

54. A medical apparatus for imaging a body cavity wall of a body cavity in a patient by interacting with a magnetic resonance imaging (MRI) system which generates a magnetic field gradient and electromagnetic (EM) radiation and transmits the gradient and EM radiation into the patient and receives a response signal indicative of a resonant response from the patient, the apparatus comprising:

an MRI antenna configured to be inserted into the body cavity and passed along the body cavity to a site to be imaged and to provide the response signal, based on the resonant response from a region of the patient closely proximate the antenna, to the MRI system.

55. The medical apparatus of claim 54 wherein the body cavity is a blood vessel and further comprising:

a controller coupled to the antenna and configured to receive the response signal and repeatedly

calculate antenna location to obtain an image of the blood vessel wall proximate the antenna.

56. A method of generating an image of a wall of a body cavity in a patient, the method comprising:

inserting a magnetic resonance imaging (MRI) antenna into the body cavity;

passing the MRI antenna through the body cavity to a site to be imaged; and

obtaining an MRI image of the body cavity wall proximate the antenna.

57. The method of claim 56 wherein obtaining an image comprises:

generating a magnetic field gradient and electromagnetic (EM) radiation and transmitting the gradient and EM radiation into the patient;

transmitting a response signal, based on a detected resonant response from a region of the patient closely proximate the antenna, to an MRI processor;

receiving the response signal at the MRI processor; and

calculating antenna location based on the response signal.

58. The method of claim 57 wherein calculating antenna location comprises:

repeatedly calculating antenna location.

59. The method of claim 56 wherein obtaining an MRI image comprises:

calculating an image of the antenna.

60. The method of claim 56 wherein obtaining an MRI image comprises:

calculating antenna position.

61. The method of claim 56 wherein obtaining an MRI image comprises:

calculating antenna orientation.

62. The method of claim 56 wherein the body cavity is a blood vessel and obtaining an MRI image comprises:

repeatedly measuring, reconstructing and storing the image to obtain an increased resolution image of the blood vessel wall.

63. The method of claim 57 wherein transmitting a response signal comprises:

capacitively coupling the antenna to an EM field generated by the EM radiation to detect the resonant response.

64. The method of claim 56 wherein the body cavity is defined by vasculature and the antenna is configured as a guidewire and further comprising:

positioning a catheter in the vasculature through use of the guidewire.